

Prerequisites, Progress and Prospects for Determining the Chemical Composition of Atmospheric Aerosols by Remote Sensing

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Spectral Requirements for Aerosol Characterization - I

- Need continuous infrared spectra to derive chemical information
- Frequency Range
 - For PSC: $\sim 700 < \nu < \sim 1800$ (cm^{-1})
 - For Cirrus: $\sim 700 < \nu < \sim 4500$ (cm^{-1})
- System SNR
 - min 200 at low frequencies
 - above 1000 mid-range

Spectral Requirements for Aerosol Characterization - II

□ Spectral Resolution

- Low or high OK but different analysis needed

□ Low (minimum $\sim 20 \text{ cm}^{-1}$)

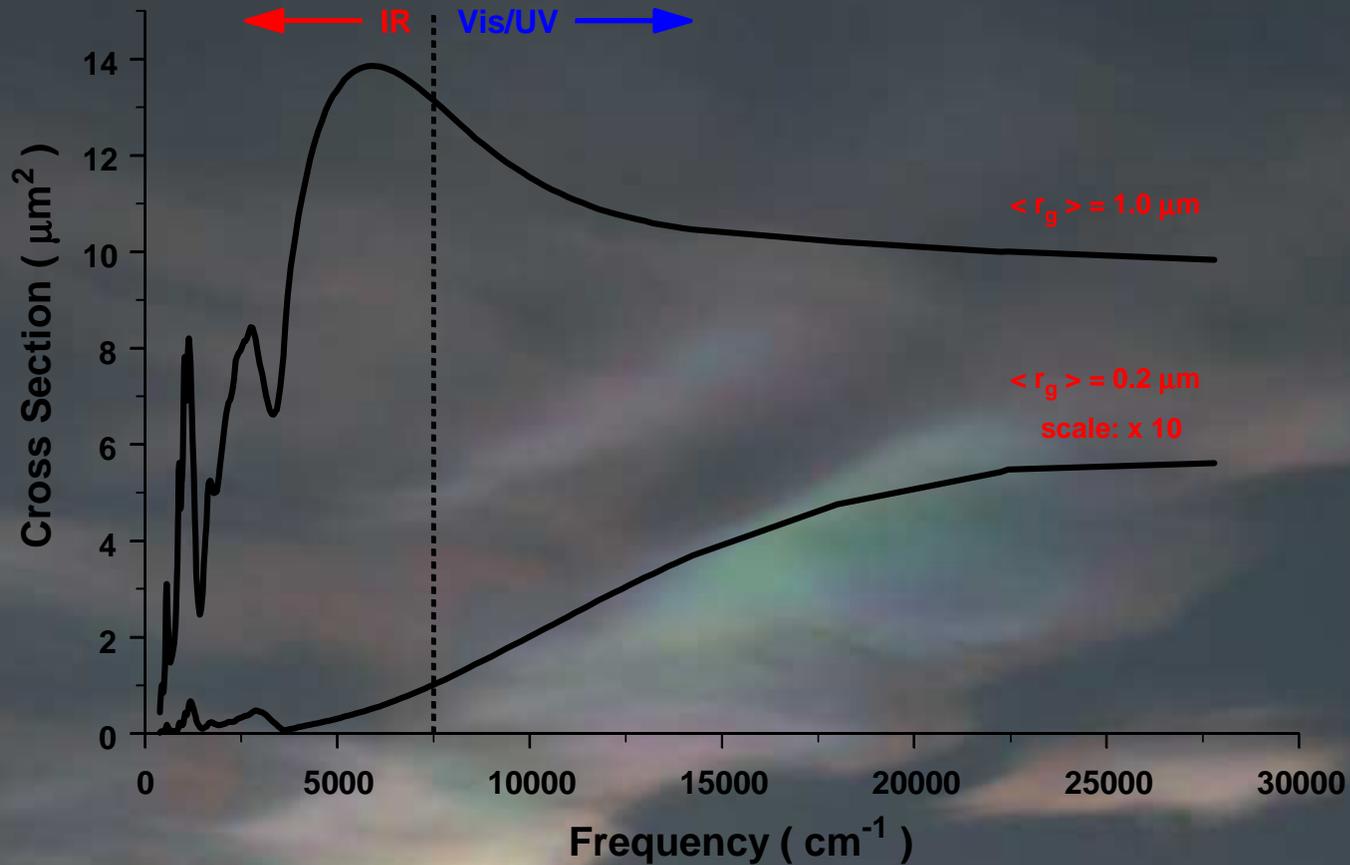
- Difficult to eliminate gas phase
- Possible to increase aerosol signal with respect to gas phase

□ High

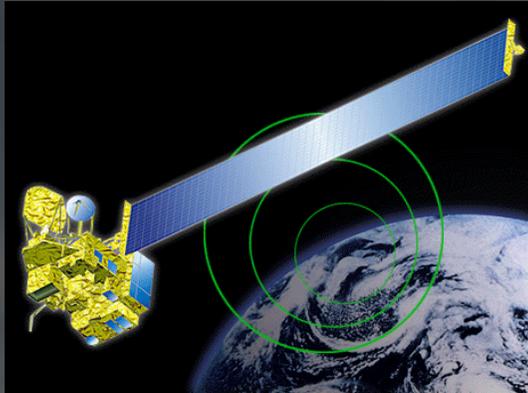
- Two step processing – remove gas phase, then analyze remaining aerosol spectrum.

H₂SO₄ Aerosol Extinction Cross Sections

(lognormal, $\sigma = 1.5$)

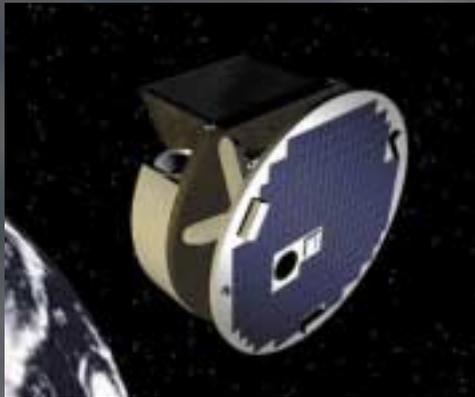


Broadband IR Satellite Instruments



ILAS-II: Grating

- 780-3,333 cm^{-1} (+ NIR)
- Launch: 2001
- Orbit: 800 km
- Sun Sync 57-72° N
65-90° S



ACE + MAESTRO

- FTIR + Vis Grating
- 750-4,100 (0.02) cm^{-1}
+ Vis/UV
- Launch: 2002
- Orbit: 650 km
- β : to 74°

High Resolution Transmission Spectra

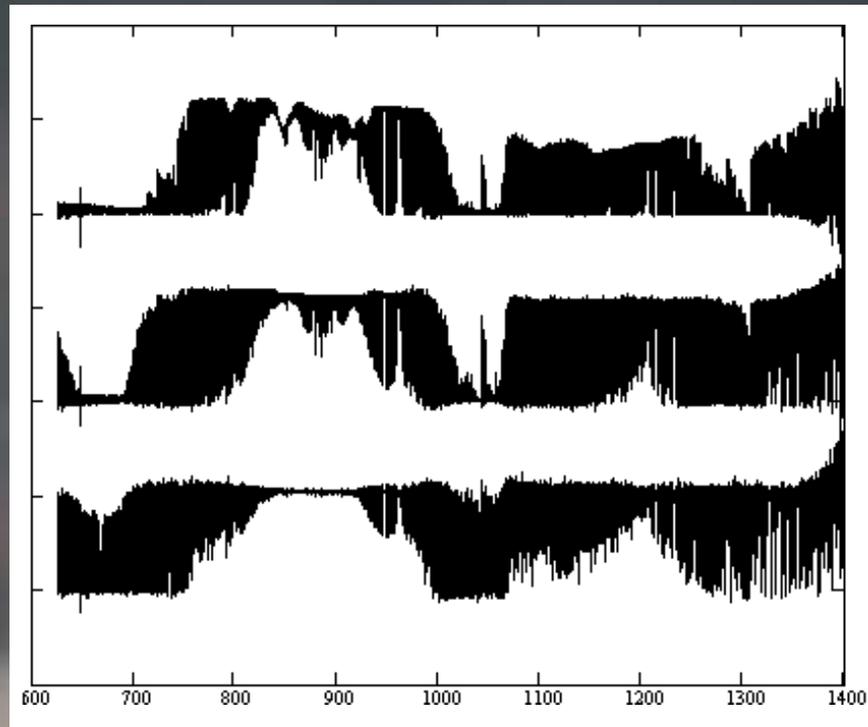
ATMOS AT2SS9

Tangent Height

Low

Intermediate

High

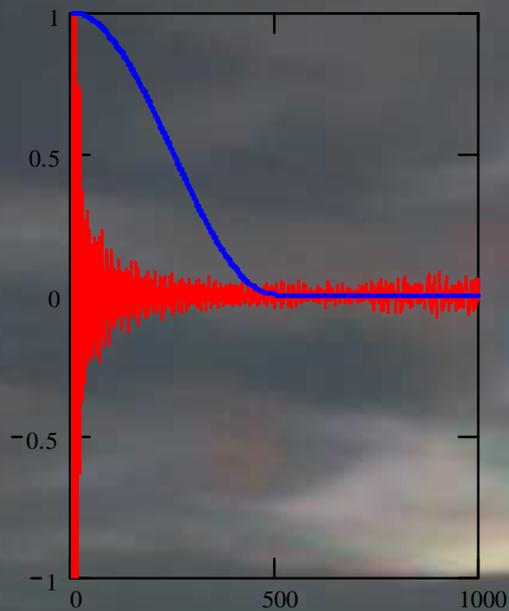


Frequency (cm⁻¹)

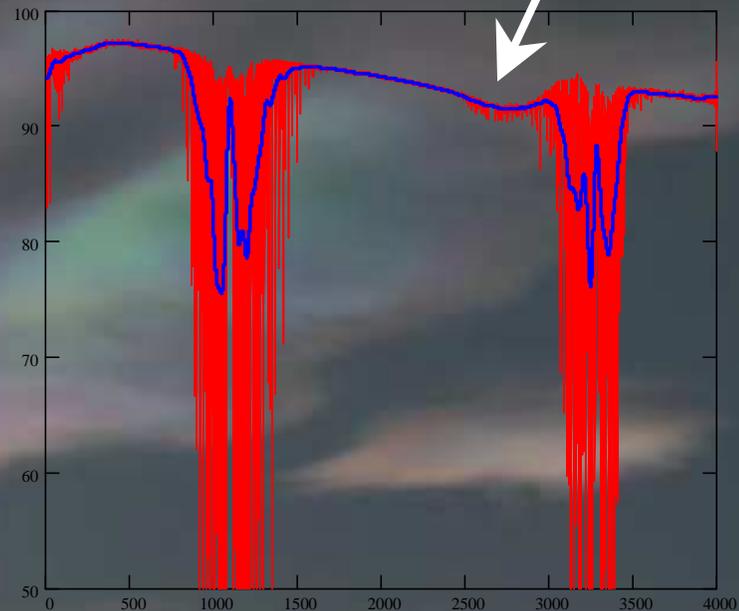
High Resolution Spectra

□ Gas phase resolved \Rightarrow potentially removable

- No simple automated method
- e.g. FT filter on water aerosol



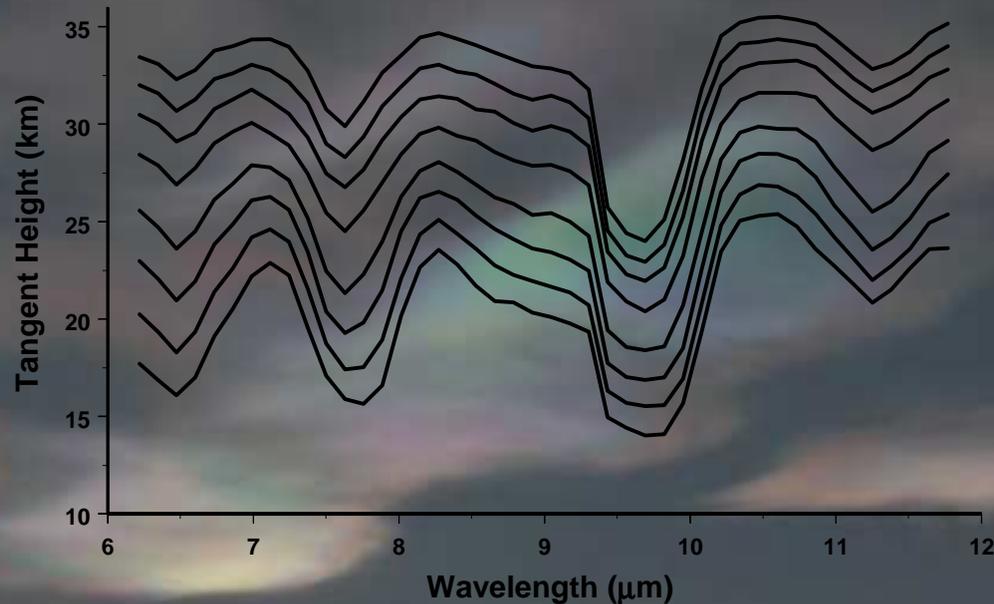
FT
⇒



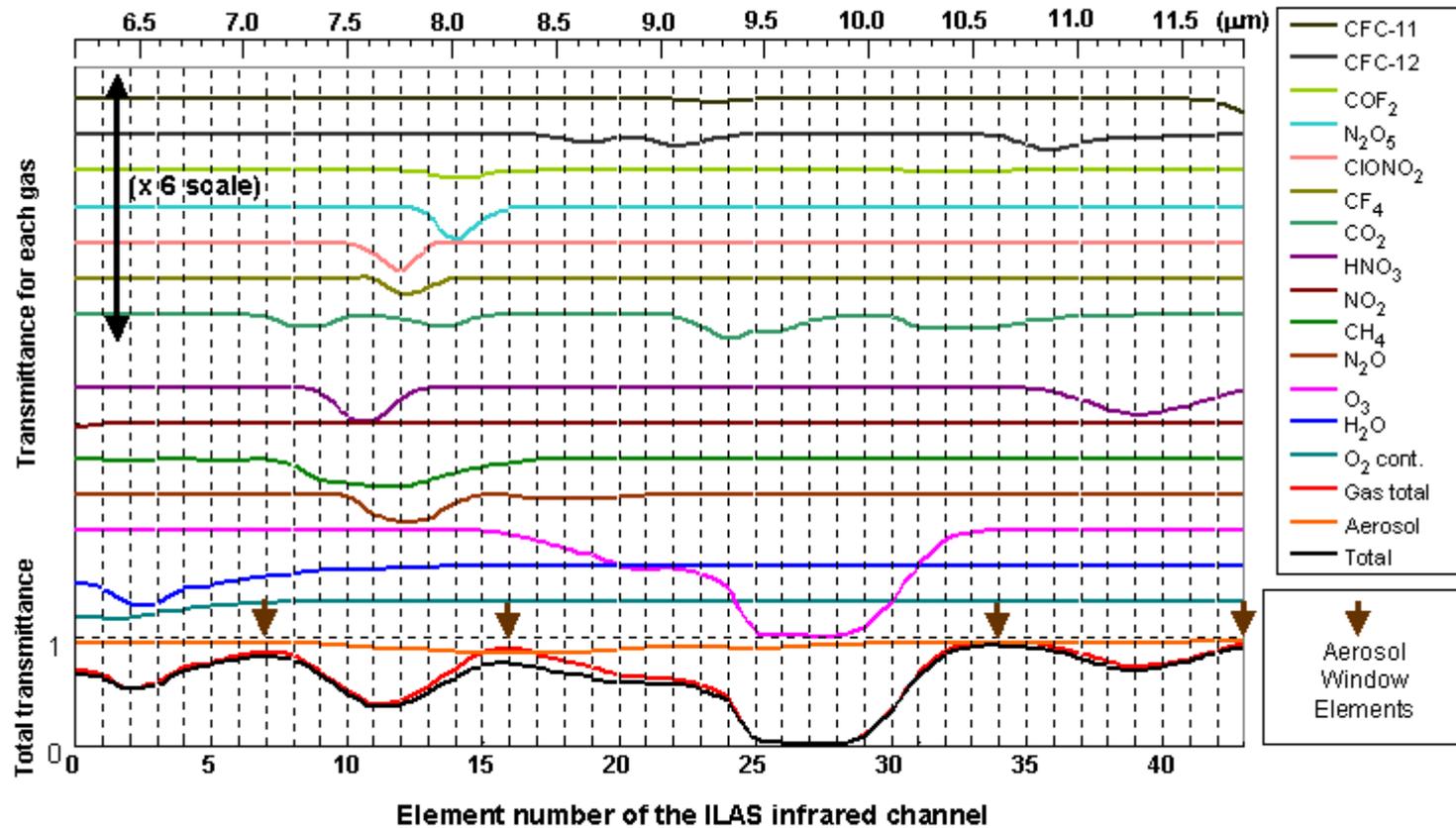
Low Resolution Satellite Spectra

□ No removal of gas phase

- Requires global data analysis methods BUT
- Aerosol data remain accessible
- e.g. ILAS- I spectra



Contributions to Low Resolution Spectra (ILAS-I NIES / NASDA, Japan)



Analysis Method

- IR spectra at adjacent tangent heights:

$$I^{\text{th}}(\lambda) = \sum A_{\text{gas}}(\lambda, P, T, \dots) + \sum [A_{\text{aer}}(\lambda, C) + S_{\text{aer}}(\lambda, r, \sigma)]$$

- Low resolution data precludes removal of gas phase interferences
- Use laboratory spectra in least squares procedure to determine aerosol contributions:

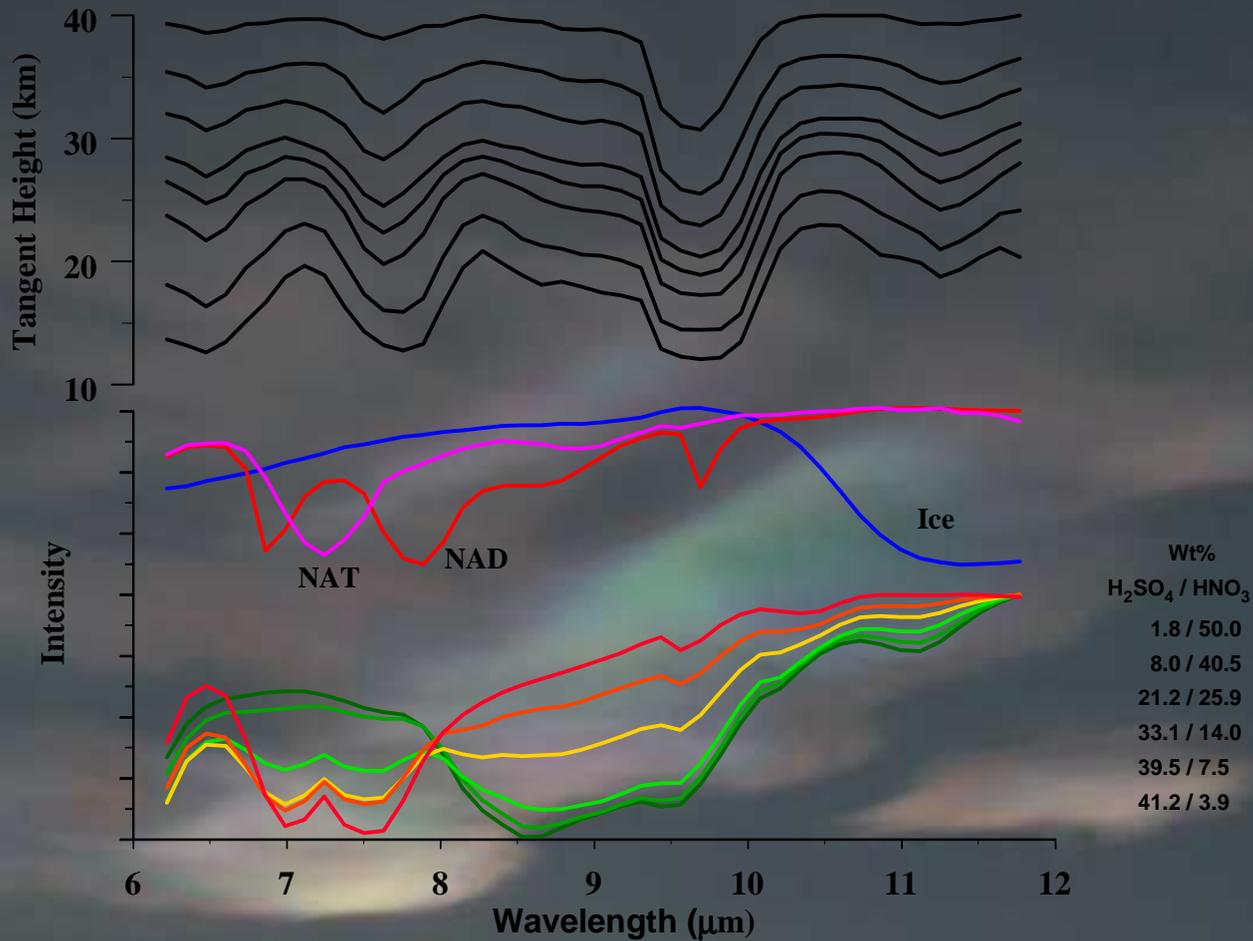
$$A(\lambda) \cdot W^{\text{th}} = I^{\text{th}}(\lambda)$$

$A(\lambda)$: Matrix of laboratory spectra.

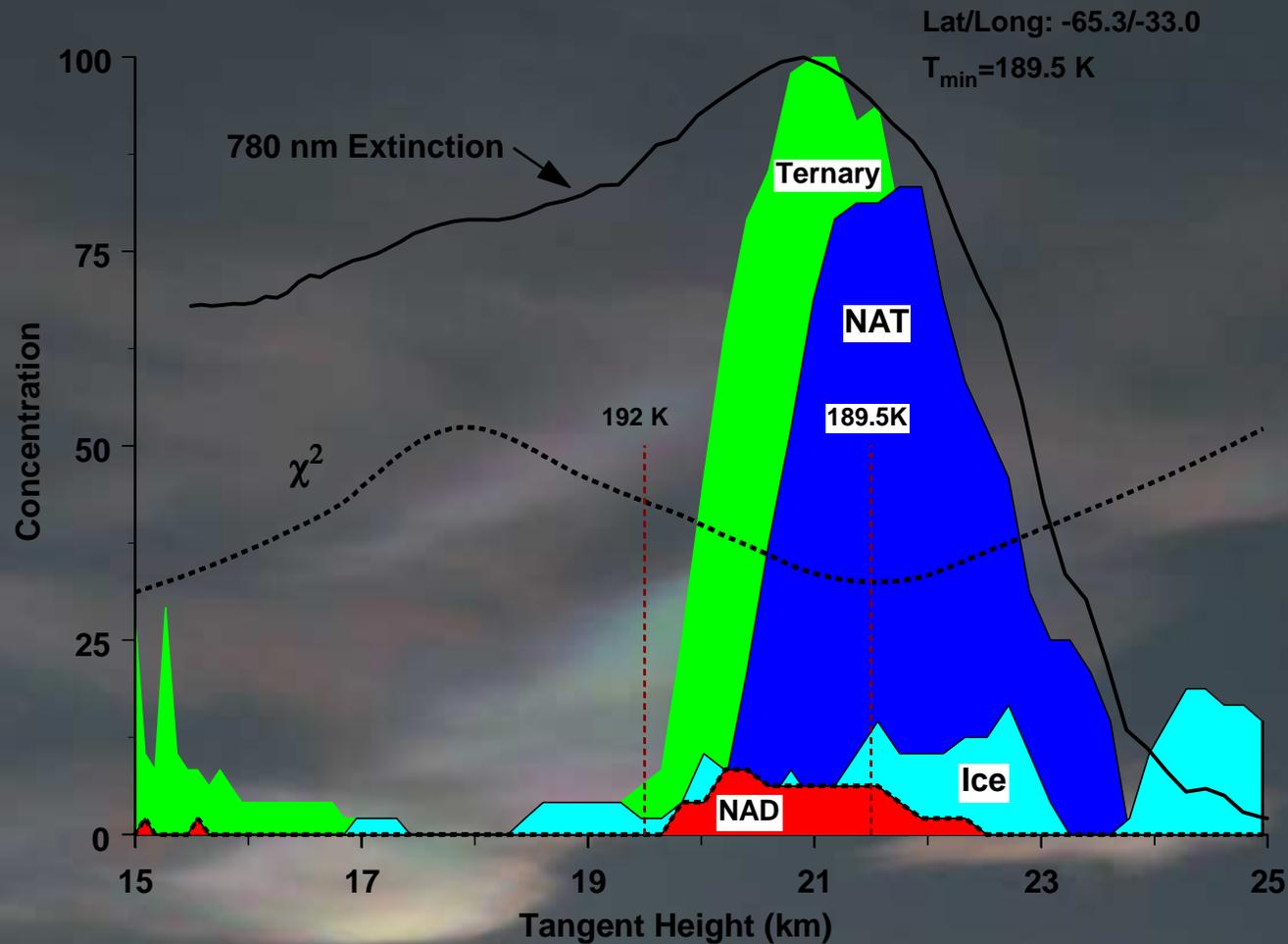
W^{th} : Particle composition at each tangent height

Satellite and Laboratory Spectra

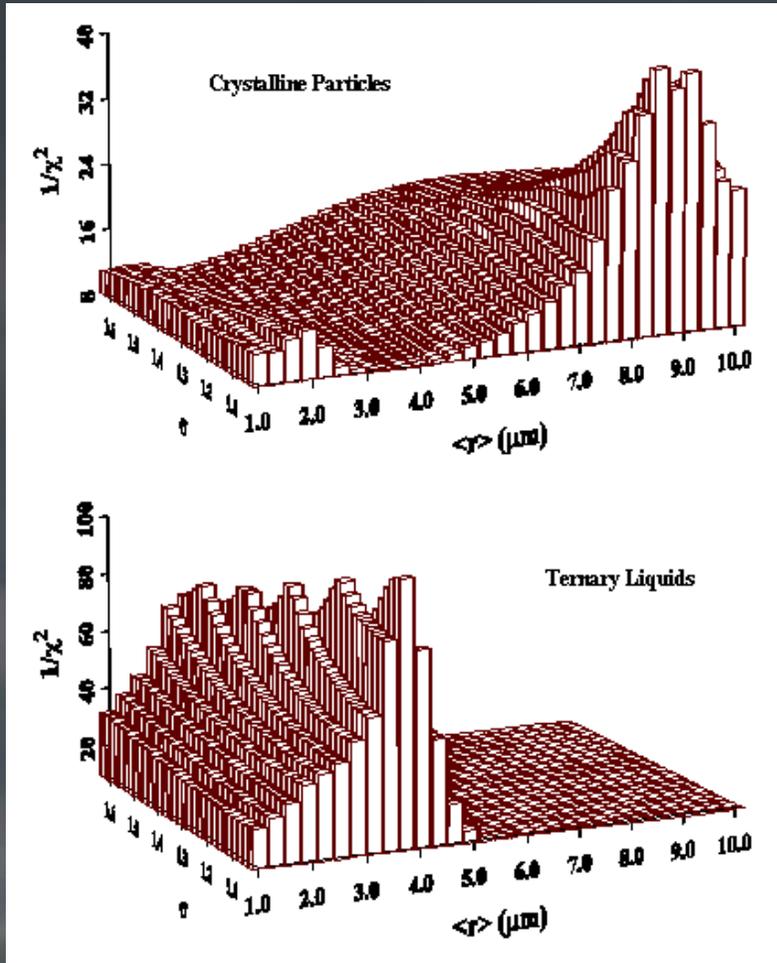
(Data used in following analysis)



Results - I (Particle Compositions)

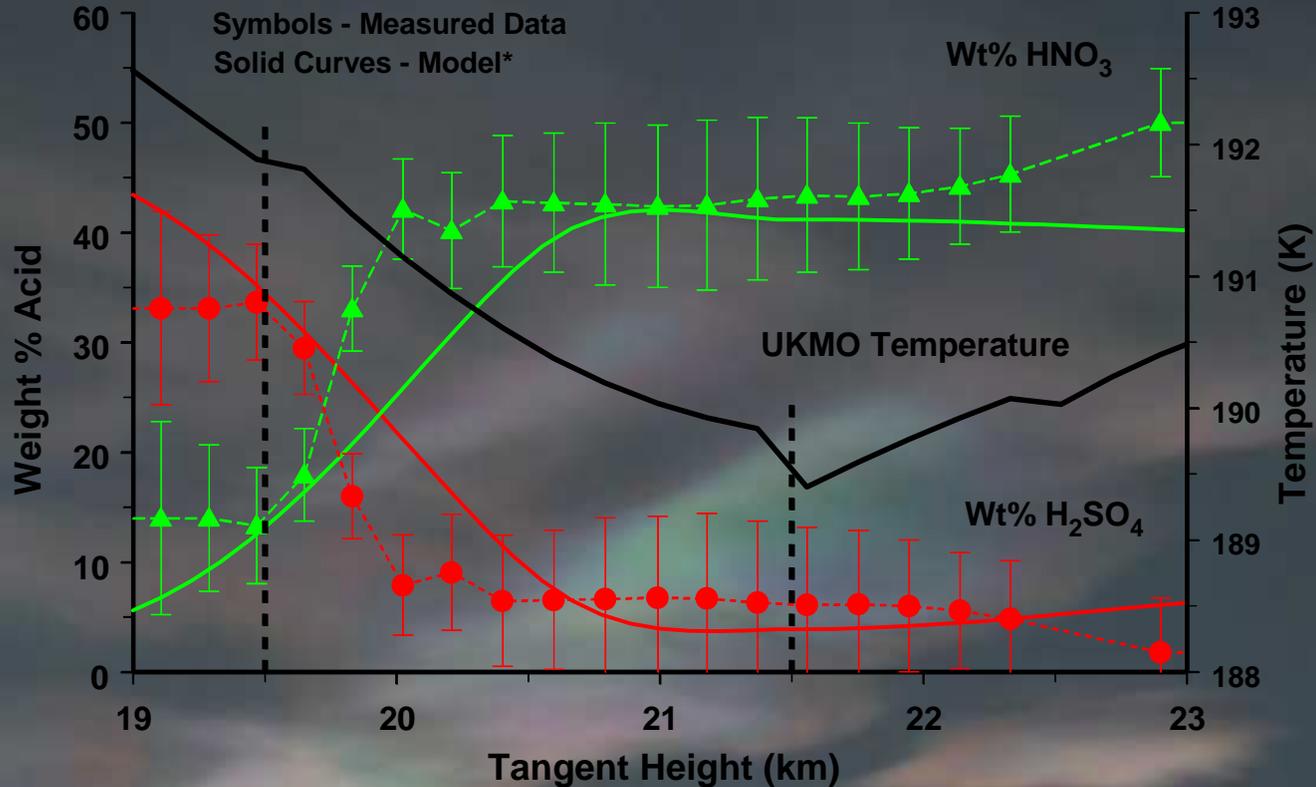


Results - II (Particle Sizes)



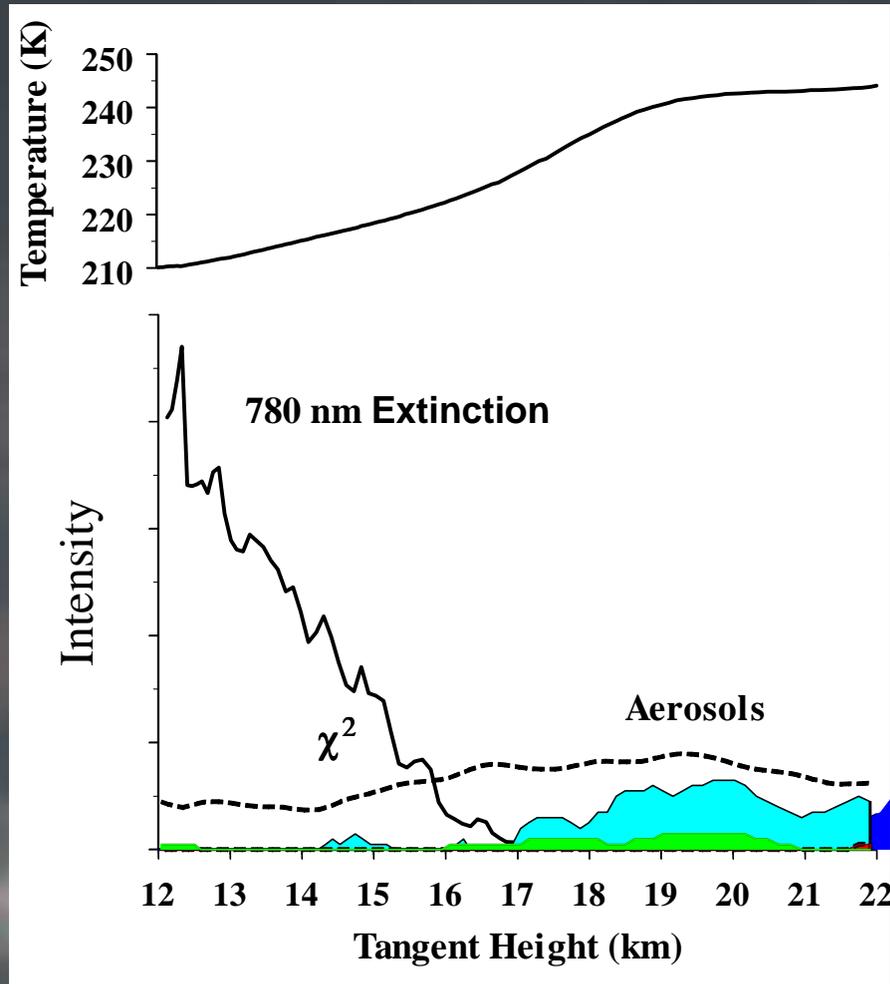
- Retain Separate χ^2 for crystalline and liquid particles
- Plot $1/\chi^2$ to show the most probable modes

Results - III (Ternary Droplet Compositions)

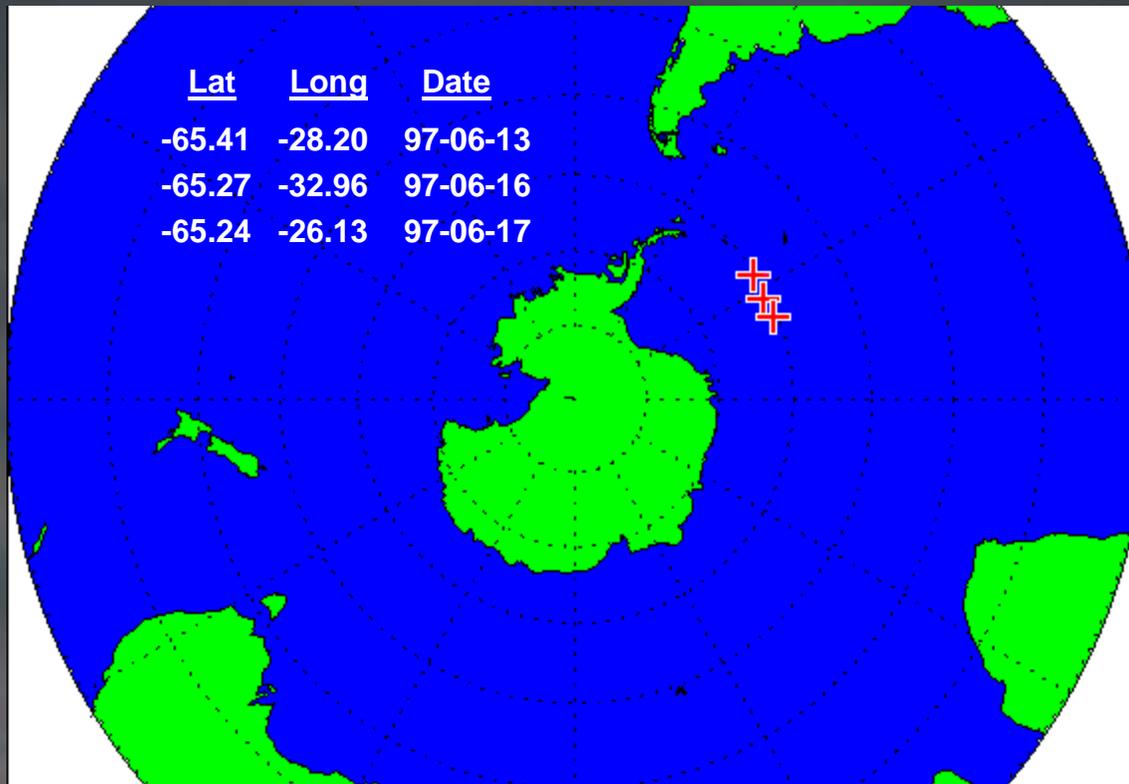


*Carslaw *et al.* J. Phys. Chem. 99 11,557 (1995)

Blank Test: Result in absence of PSC

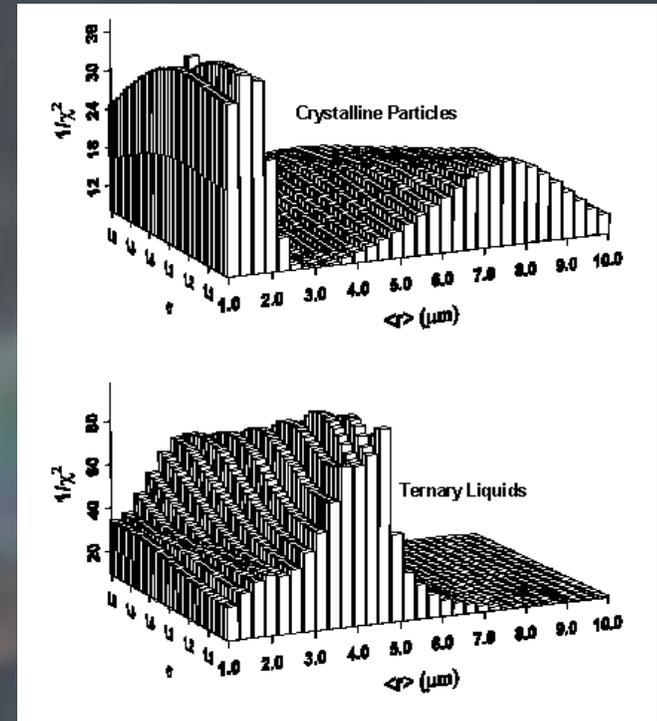
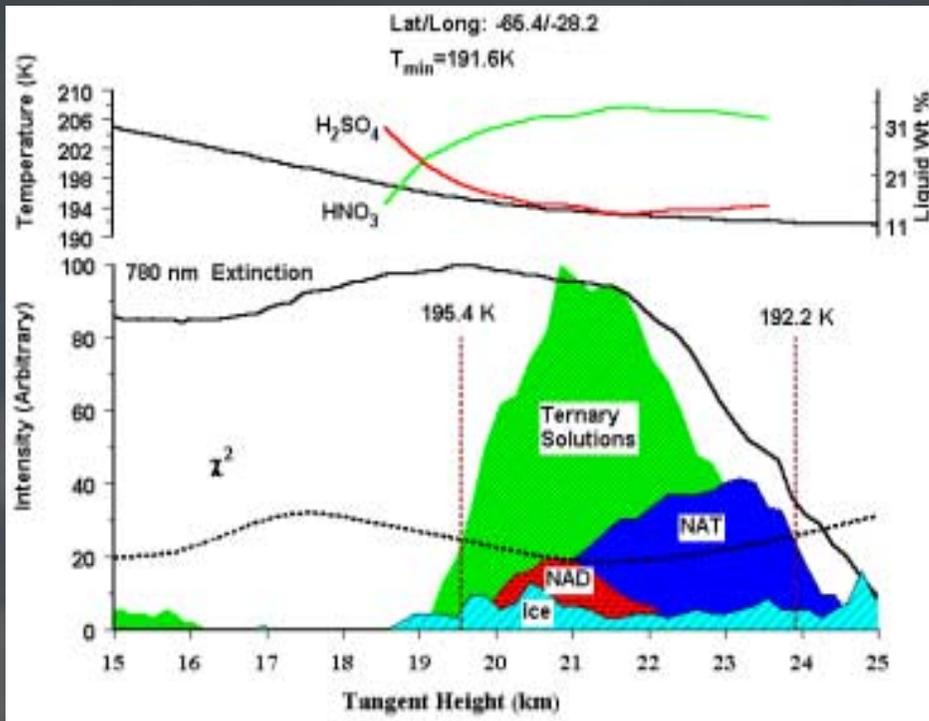


Results for Southern Hemisphere ILAS-I Observations



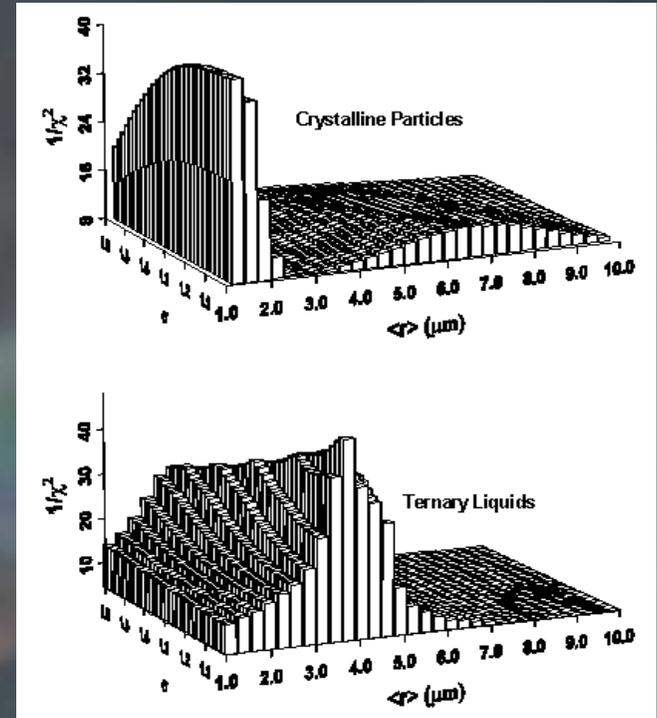
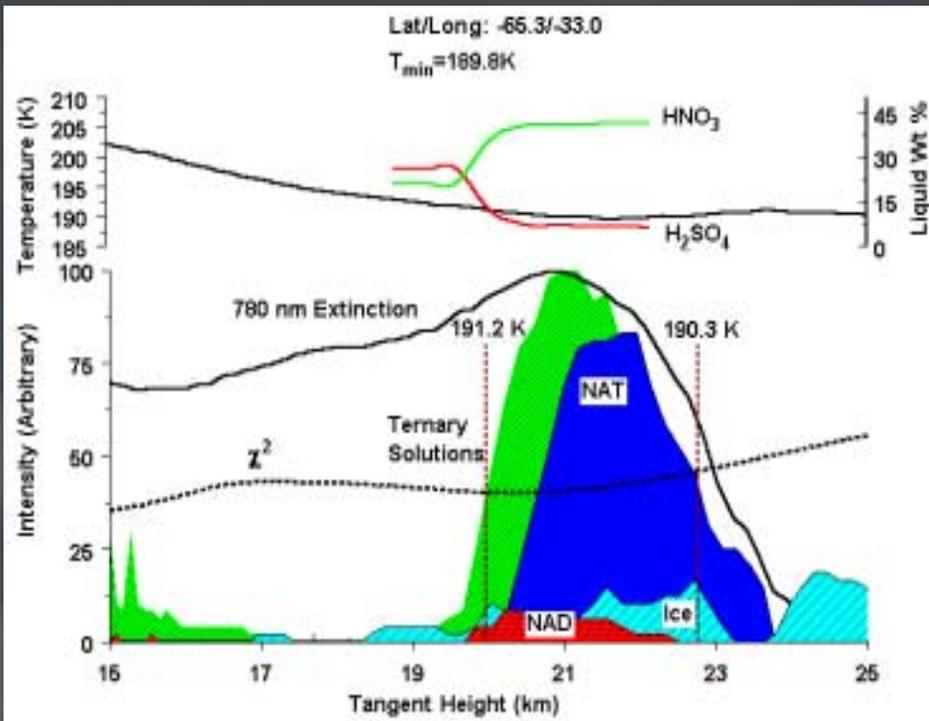
PSC Properties (S.H.)

Occultation 97-06-13



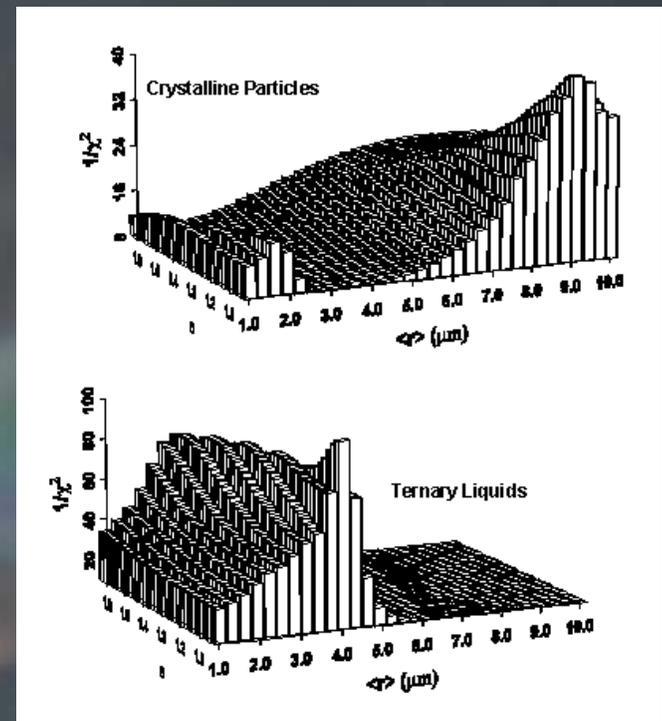
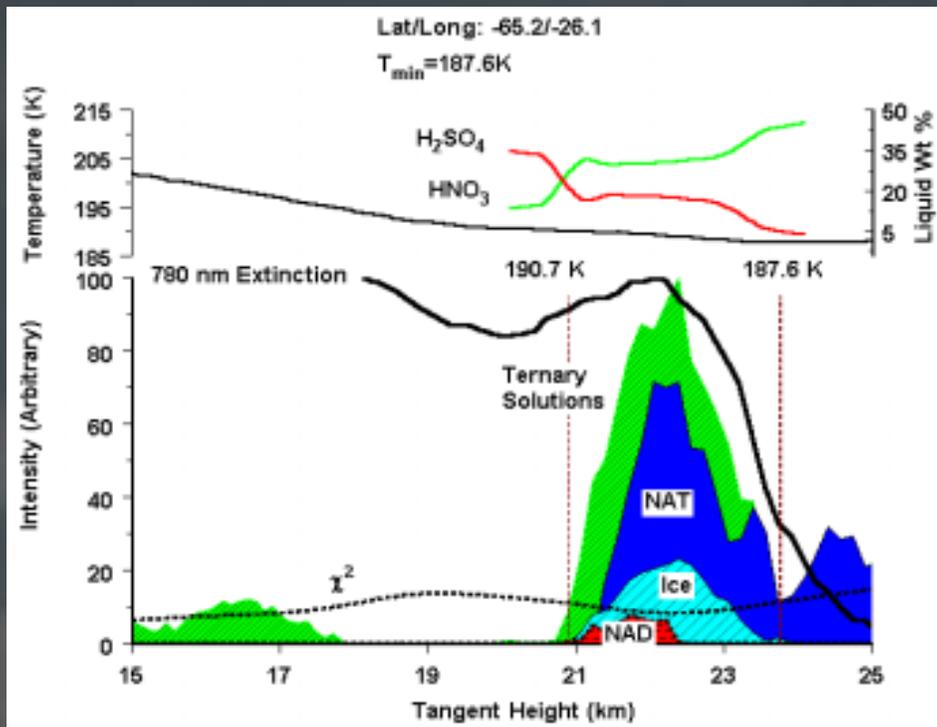
PSC Properties (S.H.)

Occultation 97-06-16

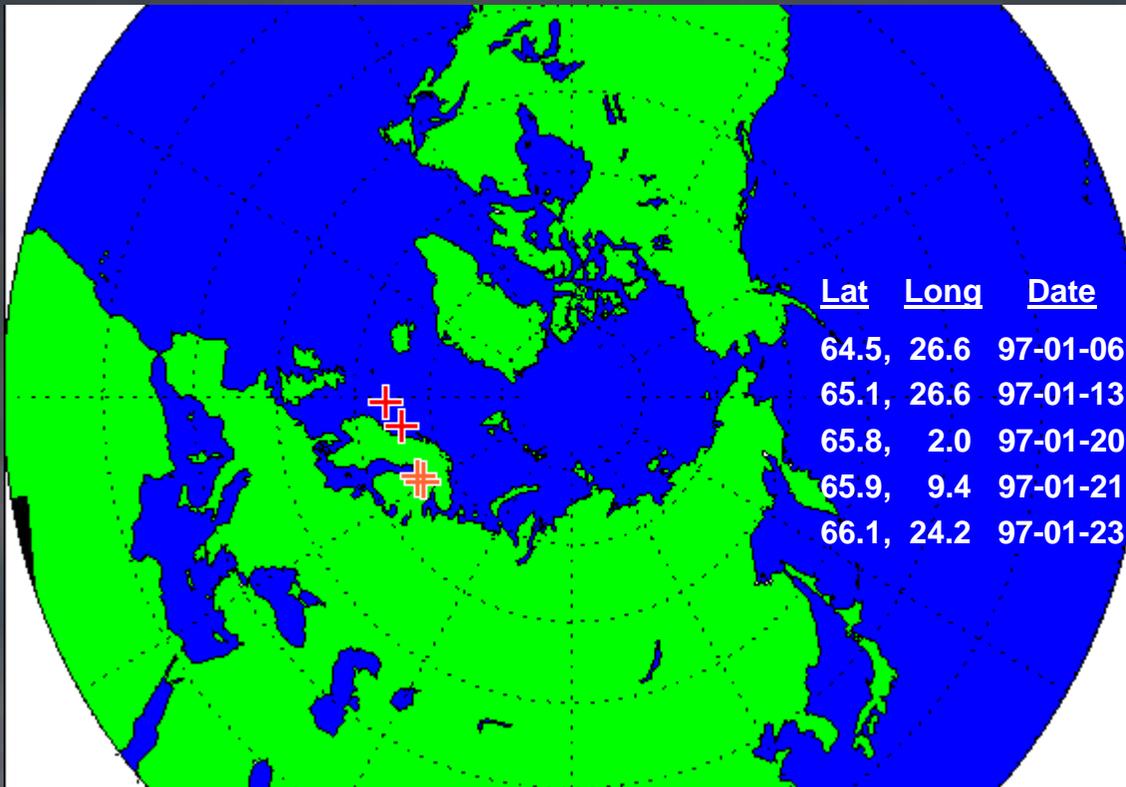


PSC Properties (S.H.)

Occultation 97-06-17



Northern Hemisphere Observations



PSC Properties (N.H.)

Occultation 97-01-06

